REMARKS/ARGUMENTS

The Office Action mailed August 2, 2004 has been reviewed and carefully considered. Claims 6 and 9-12 are canceled. Claims 1-5 and 7-8 are pending in this application, with claim 1 being the only independent claim. Reconsideration of the above-identified application, in view of the following remarks, is respectfully requested.

In the Office Action mailed August 2, 2004, claims 1-5 and 7-8 stand rejected under 35 U.S.C. §103 as unpatentable over U.S. Patent No. 4,144,811 (Barnett) in view of U.S. Patent No. 6,050,190 (Knauer), U.S. Patent No. 5,925,496 (Ghosh) and Applicant's Admitted Prior Art (AAPA).

As we have stated in previous responses, the present invention relates to a solution for the problem caused by localized differences in temperature of a blanket on a transfer cylinder caused by non-uniform heating of the blanket and the resultant deformations which may occur in the transfer cylinder due to the localized temperature differences (see, e.g., page 4, lines 17-19). According to the present invention, the solution involves making a transfer cylinder with a body made of a metallic material having a linear coefficient of about $\alpha < 5 \times 10^{-6}K^{-1}$ in a temperature range of from about 20° to about 60°. More specifically, the metallic material is an iron alloy having 30% to 40% nickel by weight.

Independent claim 1 expressly recites that the printing cylinder is a transfer cylinder on which a blanket cylinder is receivable in which localized temperature differences may occur. That is, the recited localized temperature differences are not temperature differences between the transfer cylinder and an ambient temperature. Rather, the recited localized temperature differences occur in the transfer cylinder such that one part of the transfer cylinder has a different temperature than another part of the transfer cylinder. Independent claim 1 further recites that the barrel of the

transfer cylinder is "made of a metallic material having a linear coefficient of about $\alpha < 5 \times 10^{-6}K^{-1}$ in a temperature range of from about 20° to about 60°."

It is respectfully submitted that neither Barnett, Knauer, Ghosh, AAPA, nor the combination thereof address the problem solved by the present invention and therefore fail to provide motivation for using a metallic material having a linear coefficient of about $\alpha < 5 \times 10^{-6}K^{-1}$ in a temperature range of from about 20° to about 60°, as the material for a transfer cylinder in a printing press.

Barnett discloses a printing machine in which printing rollers 52 carry the print type on printing saddles or plates (see Fig. 2 and col. 5, lines 53-55). The printing roller 52 prints directly onto a paper web 48 which passes between the printing roller 52 and an impression roller 50. Form rollers 14, 16 transport ink to the form cylinder during printing (col. 5, lines 61-65). The pressure and the amount of ink transferred by the form rollers 14, 16 to the form cylinder 52 is adjustable by adjustable bearings 10, 12. Barnett teaches that changes in the temperature have an expanding effect on the printing cylinder due to coefficient of expansion (col. 4, lines 2-25). The form rollers may be adjusted to overcome this thermal expansion (col. 4, lines 26-32). Accordingly, Barnett teaches that detrimental effects of thermal expansion of a printing roller may be counteracted by adjusting a position of the form cylinders which supply ink to the printing roller.

We previously argued that Barnett fails to disclose the problem caused by localized temperature differences. In response to our argument, the Examiner alleges that col. 4, lines 2-14, of Barnett discloses localized temperature differences. However, this portion of Barnett actually discloses that the ambient temperature increases during operation and that a temperature change of 10°F in the temperature of a print cylinder may occur. However, this does not mean that there is a localized temperature difference <u>in the transfer cylinder</u>, as recited in independent claim 1. Rather,

this section of Barnett indicates that the temperature of the entire transfer cylinder increases. As stated in col. 4, lines 17-20 of Barnett, the problem to be addressed by Barnett is the change in diameter of the cylinder which is caused by an increase in the overall temperature of the cylinder. Barnett addresses this problem by adjusting a position of the cylinder in response to changes in the diameter. However, uneven deformation caused by localized temperature changes on the cylinder would <u>not</u> be addressed by the solution according to Barnett. Accordingly, Barnett fails to address the problem caused by localized temperature differences on the transfer cylinder.

We also previously argued that Barnett fails to disclose a transfer cylinder. In response, the Examiner alleges that col. 4, lines 14-15, of Barnett disclose a transfer cylinder. However, this portion of Barnett referred to be the Examiner states: "Typically printing cylinder are formed of steel or aluminum, some of which are encased in rubber sleeves." This section of Barnett is expressly drawn to a "printing cylinder" and not a transfer cylinder or blanket cylinder. As is known, printing cylinders for flexographic printing use printing plates made of rubber, plastic, or some other flexible material (see Attachment 1). Since Barnett specifically refers to "printing cylinders", the mention at col. 4, lines 14-15, in Barnett that some printing cylinder may have rubber sleeves can only refer to flexographic type printing cylinder and <u>not</u> transfer cylinders or blanket cylinders. Accordingly, col. 4, lines 14-15, of Barnett can not be considered to disclose a transfer cylinder. Rather, this section of Barnett discloses a printing cylinder with a rubber sleeve, as used, for example, in flexographic printing.

The Examiner further states that he relies on Barnett for motivation for using material having the characteristics claimed by the present invention. However, Barnett discloses a solution for counteracting expansion and/or reduction in the diameter of a printing cylinder caused by temperature changes. Since Barnett provides a solution for addressing changes in diameter, there

is no motivation for a person skilled in the art to find other solutions such as using different materials. As described above, Barnett does not address the problem of localized temperature differences. Rather, Barnett addresses the problem of an overall temperature change which causes changes in the diameter of the cylinder.

In view of the above remarks, Barnett fails to disclose, teach or suggest a printing unit cylinder comprising a transfer cylinder "in which localized temperature differences occur, said printing unit cylinder comprising a body having a barrel as a centerpiece and two journals, a respective one of the journals being on each end of the barrel; the entire barrel being made completely of a metallic material having a linear coefficient of expansion of about $\alpha < 5 \times 10^{-6}K^{-1}$ in a temperature range of from about 20° to about 60°", as expressly recited in independent claim 1.

Ghosh fails to teach or suggest what Barnett lacks. Ghosh discloses an anodized zirconium metal lithographic printing members. The object of Ghosh is to provide a ceramic lithographic printing plate that has great strength, fracture resistance and wearability. There is no specific teaching regarding the coefficients of expansion of the cylinder. Ghosh fails to provide any motivation for using a metallic material having a linear coefficient of about $\alpha < 5 \times 10^{-6}K^{-1}$ in a temperature range of from about 20° to about 60°, as the material for a transfer cylinder in a printing press, as expressly recited in independent claim 1. Even if the materials taught by Ghosh were used in Barnett, the combination still fails to teach or suggest the material of the claimed invention. Furthermore, Ghosh also fails to provide motivation for conteracting the effects of localized temperature differences on the transfer cylinder because Ghosh does not address the subject of thermal expansion. Accordingly, neither Barnett nor Ghosh includes any motivation or suggestion for the making the entire barrel of the transfer cylinder completely of a metallic material having a

linear coefficient of expansion of about $\alpha < 5 \times 10^{-6}K^{-1}$ in a temperature range of from about 20° to about 60°, as expressly recited in independent claim 1.

The AAPA merely discloses the existence of a metallic material having a linear coefficient of about $\alpha < 5 \times 10^{-6}K^{-1}$ in a temperature range of from about 20° to about 60°. There is no motivation for using such a material for a transfer cylinder in a printing press, as expressly recited in independent claim 1. The mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16 USPQ2d 1430 (Fed. Cir. 1990). That is, not every known material is known for every conceivable use. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). As specified in the MPEP and as further noted by the Federal Circuit, "one cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention". *In re Fine*, 837 F.2d 1071, 1075, 5 USPQ2d 1596, 1600 (Fed Cir. 1988). The motivation to use the claimed material is supplied only by the present disclosure.

Knauer is merely used by the Examiner to show journals. Knauer does not teach or suggest using a material having a linear coefficient of about $\alpha < 5 \times 10^{-6}K^{-1}$ in a temperature range of from about 20° to about 60°, as expressly recited in independent claim 1.

In view of the above remarks, independent claim 1 is allowable over Barnett, Knauer, Ghosh and AAPA.

Dependent claims 2-5, 7, and 8, each being dependent on independent claim 1 are allowable for at least the same reasons as is independent claim 1.

In view of the above remarks, the present invention is deemed to be in form for allowance and early notice to that effect is earnestly solicited.

Respectfully submitted,

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Printing Industry

Table of Contents Keys to Using Guide U.S. Domestic Printing Industry Emerging Technologies P2 Practices in Printing Lithography Screen Printing Flexography Gravure

Flexography

Overview

Flexographic printing uses a printing plate made of rubber, plastic, or some other flexible material. Ink is applied to a raised image on the plate, which transfers the image to the printing substrate. The fast-drying inks used in flexography make it ideal for printing on materials like plastics and foils. This makes flexography the predominant method used for printing flexible bags, wrappers, and similar forms of packaging. The soft rubber plates are also well-suited to printing on thick, compressible surfaces such as cardboard packaging. Inks used in flexography are usually either water-based or solvent-based (Pferdehirt, 1993).

The print area or image consists of a raised surface, known as relief printing, that can be inked and pressed onto the substrate. Non-image areas are below the printing surface and do not reproduce (Price, 1994). Both sheet-fed presses and web presses are used in flexographic printing. A diagram for flexographic printing is shown in Figure 9.

Figure 9. Principle of Flexography

All original text, pictures, and illustrations are photographed to convert them into the proper positive or negative films to make the plate which reproduces the image on the substrate. This step includes the use of photographic chemicals, paper, and film. The plates are made photomechanically, using a flexible material such as plastic or rubber, and coated with solutions to make certain areas insoluble in water. Wastewater from this process may contain acids, alkalis, solvents, plate coatings, and developers. If using metal plates, non-image areas are etched with an acid solution that result in high concentrations of heavy metals in the waste water. If using rubber or plastic plates, no metals are introduced into the waste water. Ink is applied to the image on the plate. From the plate, ink is transferred directly to the substrate. Wastes associated with this process are waste paper, waste ink, and cleaning solvents. Air emissions containing VOCs from inks and cleaning solvents are important waste streams (Price, 1994).

Flexographic printing has considerable impact on the environment based on the use of rubber and photopolymer plates, solvent-based inks, and hydrocarbon solvents, as well as a broad range of substrates. Printers select and mix chemicals for a variety of prepress and pressroom applications. Darkroom chemistry, platemaking, inks and solvents, and maintenance all use chemicals to achieve the ultimate goal of transferring a quality image to a substrate (Shapiro, 1993a).

The traditional flexographic operation has many large, open containers for inks and solvents which are used in the printing process. These evaporate rapidly into the plant and are emitted through the exhaust stacks. Process waters are discharged from darkrooms, cleaning tanks and cooling systems. Water-based inks may result in cleanup wastes going to sewers or septic tanks. Adhesives used in converting may also find their way into the water discharges. These wastes may still be considered to be hazardous in some states depending upon their composition. The state regulatory agency will be able

to provide guidance on this issue. The manufacture of engravings for rubber plates and photoploymer plate processing introduce sources of air, water and hazardous wastes (Shapiro, 1993a).

Prepress

Plate Preparation

Citrus-based solvents and other more acceptable solvents have replaced the traditional chlorinated solvents available to plate shops and printers who make photopolymer plates. Water-washable photopolymer platemaking systems are now on the market. These are usually classified as nontoxic, noncarcinogenic, and noncorrosive (Thompson, 1994).

Photopolymer masters have been introduced for making rubber plates. The hard photopolymer replaces the metal engraving. Laser-engraved rubber plates have also been introduced and provide a chemical-free means of platemaking. Future improvements might be in the area of reuse and recycling of photopolymer plates, trim scrap and polyester cover sheets, and further packaging reduction/reuse (Thompson, 1994).

In-line platemaking systems are fully enclosed and have microprocessor-controlled exposure with processor and dryer/light finisher units. Light finishing via UV sources with advanced automation and computerized controls ensures accurate platemaking and reduced operator handling. These systems work well with a solvent-reclamation unit (Thompson, 1994).

Press

Inks

Water-based inks have been used most broadly among flexographic printers, especially when printing on paper substrates such as corrugated containers. The first large-scale testing of water inks on film and foil substrates occurred in late 1979 and continued throughout 1980. In general, flexographic printers made the switch before it was required. Trials began with white ink, which represents the largest ink usage for the majority of flexographic printers. Early problems included poor adhesion, poor wet rub properties, low gloss, and reduced press speeds (Morris, 1986). The poor adhesion has been particularly troublesome with frozen food packaging.

Water-based ink technology has improved to the point where it is in the mainstream of film printing. The colors produced are more vibrant and crisp than their oil counterparts (Price, 1994). Films need further development to tailor them for the wetting-out and adhesion of water-based inks. Inking and drying systems need modifications to achieve more effective transfer and drying of water-based inks. In addition, there is a need for cleaning systems that will facilitate the removal of all ink components and extend the life of anilox rolls and doctor blade systems (Shapiro, 1993b).

With water-based inks, the surface tension causes beading (ink that will not "lay down") that produces sharp process dots with less tendency to bridge. Printers capitalize on that by using ceramic anilox cylinders and plates that release the ink more readily to the substrate. Good ink trapping insures good process printing. To accomplish good dry trapping one must increase the negative pressure on the in-between driers to accommodate the increased expansion of water compared to alcohol, i.e., increase warm air movement. Enclosed ink systems and ink temperature control can reduce amine loss and retain the color strength at the original viscosity. Water-based inks dry in a 3-step process; water

evaporates from the ink, amines must leave the ink for the ink to have water resistance, and the polymer emulsion particles must join to create a film or network in the dried ink film. Water inks are more stable in high humidity conditions and do not suffer solvent loss and the resulting changes in viscosity that solvent inks do. To maintain good process printing with water-based inks, it is necessary to prevent excessive mechanical agitation, maintain suitable pH, keep temperatures below 110 ^{o}F, refingerprint press using water inks, and change to ceramic anilox cylinders (Matthiesen, 1993).

A new class of water-dispersible polyester resins is finding application in water-borne flexographic printing inks and overprint lacquers. Unlike other aqueous ink systems that rely on relatively high acid resins for water dispersibility, the new polyesters require no neutralizing agents, such as ammonia or amines, to maintain water dispersibility. The need to balance ink pH on the press is thus unnecessary, and odor problems associated with volatile amines are avoided. These polyester systems dry faster on the substrate, allowing faster press speeds or lower oven temperatures, and they exhibit rewettability on the press (cylinders, plates, anilox rolls). This is all made possible because the linear aromatic polyesters contain sodiosulfo groups (Barton, 1991).

Achievements in doctor blade technology have resulted in high quality flexographic printing and pollution prevention through controlled ink transfer from the ink container to the substrate. The average two-roll system with its ink fountain, fountain roller and anilox roll is a veritable open reservoir, exposing large quantities of solvents that are readily evaporated. The chambered doctor blade halts this evaporation. Ink enters the chamber from the reservoir or ink sump by a pump. The ink is held in the manifold area, with a small area exposed to the anilox roll. A doctor blade is positioned to shear off the excess ink as the anilox turns, returning all extra ink to the chamber. A second plastic or metal blade retains the ink within the chamber. The chamber is sealed off completely so that no ink goes beyond the width of the unit. Anilox roll technology has advanced to accommodate the wear of the doctor blade. When cleaning anilox rolls, use automated systems with ultrasonic or high-pressure, and liquid cleaning (versus mechanical) to reduce damage to rolls or cells.

Chrome-plated rolls have been replaced by laser-engraved ceramic surfaces. The blades now wear instead of the roller (Shapiro, 1993b).

By using the chambered doctor blade system and other related improvements, the fountain and the ensuing solvent exposure and evaporation have been reduced. The only ink solvents evaporating are those carried by the anilox roll to the printing plates and then to the substrate. No matter what the press speed, the ink amount deposited using doctor blades will be consistent. Laser-engraved ceramic rollers wear better with the doctor blade in place. An innovative chamber blade system with automatic washing system (automatic blanket cleaners and ink levelers) built into the unit solves problems of ink remnants and reduces the amount of water previously used to clean the printing system (Price, 1994.) Some continuing problems with the blade systems include end-seal leaks, inks spitting-up from seals on impression drums, set up and cleaning time on chamber systems, and part corrosion with water-based inks (Shapiro, 1993b).

Several new and innovative drying and curing technologies have been developed that reduce energy costs and work well with new ink formulations (Wold, 1991). Infrared drying uses electromagnetic radiation and high energy concentration. It requires moderate capital cost, and has high operating costs; it is often used in conjunction with convection air dryers to provide the sensible heating load to the coated web. Radio frequency uses high frequency electrical energy to dry water and solvent based coatings using high energy concentration. There are high capital costs and moderate operating costs.

Supplemental convection air dryers are sometimes used in conjunction with radio frequency.

Post Press

Refer to the general pollution prevention section.

Letterpress

Like flexography, letterpress uses a plate with a raised image on a metal or plastic plate. Once the predominant printing method, today it is used primarily for printing books, business cards, and advertising brochures. The use of letterpress continues to decline dramatically with lithographic, gravure and flexography replacing what was once done by this technique.

The three types of letterpresses in use today are the platen, flat-bed, and rotary presses. On the platen press, the raised plate is locked on a flat surface. The substrate is placed on another flat surface and pressed against the inked plate. The flat-bed cylinder press prints as the substrate passes around an impression cylinder on its way from the feed stack to the delivery stack. These presses are often very slow relative to lithographic, flexographic or gravure presses. The most popular letterpress is the web-fed rotary letterpress (US EPA, 1995).

References Used

Barton, K.R. 1991. Water-based inks based on a new class of polyester resins. Polymers, Laminations & Coatings Conference. 1991.

Matthiesen, D. 1993. Water Based Inks: Techniques in process printing. TAPPI Second Annual Converting Short Course. May 1993.

Morris, John. 1986. "Low Solvent Ink Technology: Where is it Now? Where is it Headed?" FLEXO, April 1986, p. 52-57.

Pferdehirt, W.P. 1993. Case Study: Roll the presses but hold the wastes: P2 and the printing industry. Pollution Prevention Review. Autumn 1993.

Price, R.L. 1994. Printing & publishing industry pollution prevention and recycling.

Center for Hazardous Material Research (CHMR) 530-4296-000. 1994.

Shapiro, F. 1993a. High-quality flexo can be environmentally responsible. FLEXO 18(8):68-71.

Shapiro, F. 1993b. Pollution Prevention. Boxboard Containers. May 1993.

Thompson, D.F. 1994. Green flexo: Converter can create competitive edge. Paper, Film & Foil Converter April 1994: 68-70.

Wold, J.L. 1991. Maintaining productivity with convection air dryers when switching fromsolvent based to water based applications including between station C.I. flexo presses. Polymers, Laminations & Coatings 1991: 305-313.

Annotated Bibliography

Barton, K.R. 1991. Water-based inks based on a new class of polyester resins. Polymers, Laminations & Coatings Conference.

This paper reviews a new class of water-dispersible polyester resins used in gravure and flexographic printing inks. The chemical nature and qualities of these new resins are discussed.

Bassemir, R.W. and R. Krishnan. 1990. Practical applications of surface energy measurements in flexography. FLEXO

This is a technical paper that deals with the surface science of printing. Surface tension of inks, viscosity, bubble pressure, and other physical properties that affect print quality are discussed.

Capristo, M.G. 1986. Water inks can offer compliance cost effiency, performance quality. FLEXO.

This paper gives some general information and statistics on switching to water-based inks and the progress that has been made in developing water-based printing processes.

Fleischman, M., F.W. Kirsch, and G.P. Looby. 1993. Waste minimization assessment for a manufacturer of product carriers and printed labels. USEPA RREL Environmental Research Brief. EPA/600/S-93/008.

This brief reports on an assessment at a plant manufacturing high density polyethylene product carriers and printed polystyrene packaging labels. Most of the waste was generated by the cleaning of printing presses and printing plates. Opportunities for minimizing solvent waste were recommended.

Kirsch, F.W. and G.P. Looby. 1990. Waste minimization assessment for a manufacturer of printed plastic bags. USEPA RREL Environmental Research Brief. EPA/600/M-90/017.

This is a report of an assessment at a plant manufacturing ~ 1.8 million lbs. of printed plastic bags for snack foods annually. The lamination process waste could be handled with an automatic adhesive/solvent mixing system.

Matthiesen, D. 1993. Water Based Inks: Techniques in process printing. TAPPI Second Annual Converting Short Course. May 1993.

This paper provides a thorough overview of the physical properties of water-based inks and how those properties affect print quality. Numerous recommendations are made on how to maintain and improve print quality.

Parsons, R., B. Donovan, and M. Hayward. Ultrafiltration for the treatment of ink and starch wastewater in the corrugated container industry.

This technical paper describes the use of ultrafiltration in treating flexographic ink wash water and dilute starch adhesive waste.

Pferdehirt, W.P. 1993. Case Study: Roll the presses but hold the wastes: P2 and the printing industry. Pollution Prevention Review, Autumn 1993.

A review of the printing industry, including a description of the basic printing processes, is given. Waste reduction opportunities are explained, along with a review of progress that has been made in pollution prevention in the printing industry.

Price, R.L. 1994. Printing & publishing industry pollution prevention and recycling. Center for Hazardous Material Research (CHMR) 530-4296-000.

Student manual prepared for the Illinois Environmental Protection Agency. This manual gives the history of the printing industry, and statistics about Illinois printing establishments. Each of the printing processes are explained and diagramed. The common pollution prevention and waste reduction opportunities are explained.

Shapiro, F. 1993. High-quality flexo can be environmentally responsible. FLEXO 18(8):68-71. The effects of environmental legislation and resulting compliance on the printing industry is discussed.

Shapiro, F. Impact of hazardous waste on the package printer/converter. FLEXO

Wastes generated at each step of the printing process are described, along with ways to minimize those wastes.

Shapiro, F. 1993. Pollution Prevention. Boxboard Containers. May 1993.

Pollution prevention and waste reduction in the boxboard industry are discussed in relation to compliance with regulations and quality manufacturing.

Shields, G.N. 1994. New method to clean anilox rools. FLEXO 19(4):36-40.

Automated cleaning systems with multiple-nozzle spray bars, and liquid-through-liquid spray cleaning are discussed.

Strutt, D.B. 1991. Photopolymers achieve new quality levels in flexographic printing. Polymers, Laminations & Coatings 1991: 337-338.

The use of photopolymer printing plates and their impact on quality and printing speed are discussed.

Thompson, D.F. 1994. Green flexo: Converter can create competitive edge. Paper, Film & Foil Converter April 1994: 68-70.

A brief overview of P2 and waste reduction opportunities in flexographic printing.

Wold, J.L. 1991. Maintaining productivity with convection air dryers when switching from solvent based to water based applications including between station C.I. flexo presses. Polymers, Laminations & Coatings 1991: 305-313.

Drying/curing technologies are reviewed. The technical aspects of drying, including heat transfer and evaporation rates, are presented along with actual data from test drying stations.

Related industries

Hang, M. 1994. Alternative Plate Processing. FLEXO 19(1): 50-52.

This article compares closed-loop solvent plate systems with water-washable plate systems as alternatives to perchloroethylene washout solutions.

Mounsey, G. 1994. Alternative Washout Solutions. FLEXO 19(4): 31.

The hazards of perc/butyl washout solutions and the benefits of alternative washout solutions are discussed.

Case Studies

Case Study 1

Replacement of Hazardous Material in Wide Web Flexographic Printing Process

Kranz, P.B., T.R. Williamson,and P.M. Randall
USEPA RREL Project Summary. EPA/600/SR-93/149. 1993.

A wide web flexographic printing firm substituted water-based inks for solvent-based inks when manufacturing flexible packaging using plastic sheet substrates (e.g., plastic bags for bread). The project objectives were to evaluate the technical feasibility, economic effect, and resulting change in VOC emissions achieved by the substitution. The technical evaluation was to quantify the reduction in both volatile and liquid-phase solid hazardous wastes. Reduction of VOC emissions by switching from the use of solvent-based inks to water-based inks required several equipment modifications and a feedstock substitution, including dryer capacity enhancement, press roller modification, ink handling equipment upgrade and installation of an in-line corona treatment system. Water-based inks containing 72.5 percent less VOC were used in place of, and combined with, traditional solvent-based inks.

For each percent increase in water-based ink use, VOC emissions were reduced 14 lb. This was based on usage of ~2250 lb. of solvent-based ink per week, resulting in VOC emissions of about 1570 lb. Typically the substitution did not adversely affect product quality or non-hazardous scrap waste generation. An average reduction of 95 percent of liquid F003 waste from waste ink and cleaning solvents resulted from operational practice changes and employee training.

The economic evaluation was completed by calculating the costs of press modifications, ancillary equipment, waste disposal, inks, and solvent. The project had a positive net present value of $39,165 and a payback period of 2.5 yr, based on 21 percent utilization of water-based ink; 100 percent utilization of water-based inks would yield a payback period of 0.54 yr.

Additional benefits from reduced VOC emissions and liquid hazardous waste have been improvements in the workplace resulting from the switch to water-based inks include reduced indoor air pollutants, reduced handling of hazardous solvents, and the appreciation by company employees of the need to make a conscious effort to further reduce waste generation.

Case Study 2

Achievements in Source Reduction and Recycling for Ten Industries in the United States

J. W. Tillman
USEPA RREL Report. EPA/600/2-91/051. 1991

Amko Plastics, Inc., in Cincinnati, Ohio is a decorative printer for packaging of consumer products, retail store packaging and industrial packaging employing approximately 280 people. By switching from solvent-based inks to water-based inks, they have minimized their volatile emissions by an estimated 88 percent. The reduction of alcohol solvent vapors has improved the ambient air quality of the press room.

The following process changes and modifications were evaluated and implemented:

- Control of pH of the ink to maintain viscosity and print quality.
- Modification of dryer heads between successive color print stations to direct heated air onto the printed film (increased drying capability for water-based inks).
- Redesign of ink metering systems for handling a higher strength ink and thinner application.
- Replace metal anilox rolls, which were having their wear-life drastically reduced, with more expensive ceramic rolls.
- Switch the fountain roll surface material to a harder durometer rubber to improve wear-life with ceramic anilox rolls.
- Develop systems and equipment to inversely vary the percentage of resin `slip additive' blended into the resin as the film was being extruded to allow high speed printing.
- Installation of larger corona treating systems for electrostatic treatment of the film surface at the higher surface tension required for water-based inks.
- Switch to foam cushion `sticky-back' from conventional `sticky-back' to compensate for the additional pressure needed with water-based inks to achieve impression.

The major costs incurred by Amko from 1984 to 1987 (exceeding $2 million) have today resulted in the ability to print with quality and productivity at the same level as U.S. solvent-based printers.

Case Study 3

Solvent Recovery from Flexographic Printing Inks

D.C. Crump

Pollution Prevention: Proceedings for the Conference "Waste Reduction - Pollution Prevention Progress and Prospects within North Carolina. Ed. Gray, et.al.

Rexham Corporation installed a two-stage distilling process at their flexographic printing plant in Greensboro to recycle used solvent. A special room was built to house the stills and all appropriate safety features were incorporated. They have found that uncut ink cannot be distilled due to charring. This onsite distillation has reduced the amount of hazardous waste to a level that changed the status of the generator to small generator.

Case Study 4

Venture Packaging, Charlotte NC.

Case Summaries of Waste Reduction by Industries in the Southeast
Waste Reduction Resource Center for the Southeast, Raleigh, NC, 1989

Venture Packaging undertook a project to replace solvent-based inks, coatings and adhesives with water-based materials to reduce emissions and the volume of ignitable waste generated. Since implementing this program in 1980, emissions have been reduced by approximately 55 percent. An additional 15 to 20 percent reduction appears possible with further application of water-based materials. The greatest success has been achieved in adhesives. Water-based adhesives are now being used for almost all production. Ink development has been more difficult and has varied with the substrate to be printed. Laminating inks have been more successful than surface-print inks.

Capital expenditures have been minimal, but experimental costs have been incurred. The alternative, the addition of incineration equipment, would be very costly.

Case Study 5

Water and Ink Waste Reduction at F.C. Meyer Company

Toxics Use Reduction Case Study
Massachusetts Office of Technical Assistance -C101-2, 8/93

F.C. Meyer Company, a Lawrence, Massachusetts cardboard box manufacturer and printer, employs 200 people operating eight printing presses over three shifts/day, five days/wk. In 1989, F.C. Meyer switched from solvent-based inks to water-based inks, and reduced its VOC emissions from 280 tons per year to less than 1,000 lbs.. per year. Performance quality was unchanged and the regulatory workload was reduced substantially. In 1992 they began to seek further waste reduction opportunities in the area of press cleaning procedures. Through employee training, and improved washing practices, the company was able to reduce wastes from 10 drums of hazardous waste to 2 drums of nonhazardous waste per week. This reduction was achieved by draining and scraping as much ink as possible before washing, and minimizing the amount of water used.

In addition to reducing the volume of wash water used, the company asked its supplier to deliver black ink with 10 percent reduced water content. Waste water was added to the black ink with no

apparent effect on the color quality of the ink. The waste water can also be added to other colors, such as gray, in smaller amounts than when added to black ink.

Reductions achieved

Solids in spent wash water were reduced from more than 30 percent to 13 percent. The volume of water used decreased by 35 percent; about one pint of water is now used each time a press is washed. By reusing most of the wash water, waste disposal has decreased from 10 to 2 55-gallon drums per week. The 55-gallon drums of waste cost ~$100 each to dispose. Implementing the reuse of ink waste water has reduced the yearly cost of waste disposal from $52,000 to $5,200.

Case Study 6

VOC Reduction at Hampden Papers, Inc.

Toxics Use Reduction Case Study, C201-1, 8/93
Massachusetts Office of Technical Assistance

Hampden Papers Inc. of Holyoke, MA, reduced emissions of VOCs by 97 percent over a ten year period by using new aqueous based acrylics developed by I.C.I. Resins US of Wilmington, MA. Hampden is a 180-worker specialty manufacturer of converted paper, film, foils, and boards with 64 production lines in a 300,000 ft^2 facility. In the 1970s they elected to pursue reduction at the source rather than emission control. The company implemented a new coating system using non- and low-VOC inks and coatings and now uses gas oven drying and electron beam curing where necessary. They have not had to purchase VOC collection and control equipment.

Hampden found that I.C.I. acrylic copolymer resin inks and coatings have fast drying characteristics. Thermally sensitive films and coatings are cured in one of the first Energy Sciences electron beam units ever installed. Infrared technology is also used to improve drying. The aqueous products have demonstrated excellent clarity and resolubility on the press.

Over a 10-year period, Hampden has reduced annual VOC emissions at its facility by 97 percent, from over 420 tons to less than 20 tons. VOCs emitted per unit of product dropped from 8.15 pounds to 0.22 pounds. Hampden increased total production by 21 percent in the same period and has realized significant savings in fire insurance premiums. The reduction of VOCs has resulted in lower compliance costs, savings on insurance premiums, and a safer work environment.

Case Study 7

A (UV) Cure That's Eco-Friendly

Graphic Arts Monthly, November 1991:S6

James River is a marketer and manufacturer of consumer products, food and consumer packaging, and consumer-related communications papers. Their product lines include brands such as Northern bathroom tissue, Brawney paper towels, Dixie cups and plates, Monterey magazine paper, and the Quilt-Rap sandwich wrap. Sales for 1990 were $5.4 billion.

In 1975 James River began using UV-cured inks, and by the mid-1980s a significant process expansion was undertaken. UV-cured inks are used in the converting process. They create the opportunity to combine multiple steps into an in-line process. These inks dry instantly and are more energy efficient, but generally cost more than conventional inks.

Case Study 8

Tubed Products, Inc. Use Reduction Case Study

Office of Technical Assistance, Commonwealth of Massachusetts
Case Study No. 31. Nov. 1995

Tubed Products, Inc., of Easthampton, MA is a manufacturer of plastic squeeze tubes and caps for the cosmetic, personal care, pharmaceutical, and household chemical market. About 40 percent of their production is decoration of tubes with specific logos and information specified by customers.

Tubed Products made the switch to ultraviolet inks and coatings over a period of 20 years. Trials with their first UV decorating line in the early 1970s showed that UV systems had significantly reduced emissions, required less energy and floor space, reduced waste ink (since UV inks do not dry on the press), and allowed them to blend base inks to achieve custom colors. In 1979, after working with coating manufacturers to develop and evaluate UV-curable tube coatings, they purchased their first production line that used UV curing for both inks and coatings. Later, `on-mandrel' UV curing equipment was designed and manufactured that allowed tubes to be printed, coated, and capped while mounted on the same mandrel, thereby eliminating the need for tube transfer mechanisms.

Conversion to UV-cured inks and coatings required new procedures for color matching, measurement of surface friction, permeation, flexibility, and non-yellowing properties. The addition of high speed presses and UV lamp systems required additional training.

The benefits of switching to UV curing have been space and energy savings; each line occupies about one-third the floor space of a comparable thermal line and about one-fifth the energy (12,000 watts per hour). Thermal lines need about 40 minutes to produce a tube, while the high-speed on-mandrel lines take only 5 minutes. UV inks and coatings contain no solvents, reducing worker exposure and environmental concerns significantly. Although the firm has not calculated the exact cost savings, they believe that switching to UV systems has been an important factor contributing to its growth in the industry, helping it to become a low-cost producer and the largest US supplier of plastic squeeze tubes.

Case Study 9

How We Anticipated and Corrected Problems When Converting to Water

F. Lamar Jones, Label America, Inc.
Flexo, July 1990

In the beginning, all press operators were very experienced, but only with solvent-based inks. During the transition from solvent- to water-based inks, customers were demanding better color matches, more consistency from run to run, and much improved light-fastness. Suppliers were not providing inks that were base color consistent, and service was poor. Other flexo converters were beginning to switch to water inks, so we looked for a supplier that would commit to us, providing both service and quality, and made the switch.

We chose one press and one pressman to experiment with the water-based inks. That minimizes disruption in the pressroom, and allowed us to "work off" the inventory of solvent-base inks. We had to make adjustments in press speed, wash-up sink, substrates, tools, and ink additives.

Press speed: We routinely run water-based inks at 400-500 feet per minute, on both gloss and uncoated stocks. We have found that movement of air is as important, if not more important, than heat, in the drying of water-based inks.

Wash-up: Water-based inks require a mild soap solution for wash-up. In order to avoid contamination of the inks with this solution, a custom wash-up sink was built. It is centrally located in the pressroom and large enough to accommodate the ink pan, bucket and pump. At the end of the job, ink is drained back into the ink container. Residual ink in the pan, bucket, and pump go to the sink where the wash solution circulates through until they are clean (about 3 minutes). Disposable pans are available, which would also reduce wash-up time.

Substrates - paper vs. film: Label America, Inc. specializes in EDP labels, both pinfed and sheetfed, so the bulk of the printing is on uncoated paper, which may be rough. Ink coverage can be improved with ink additives. Our experience has been that with proper primer and specially formulated inks, we can effectively print on films and foils with excellent results.

Tools: With the switch to water-based inks, we had to make more use of Zahn cups and pH meters to maintain the ink quality.

Ink maintenance: Replenishment is added as needed, and the pH meter is used often.

Ink additives: Slow, medium, and fast dry reducer, print cleaning additive, glycol, ammonia, extender and color boosters are all being used to improve print quality

Computerized ink mixing: This is among the most significant changes for Label America, Inc. It has paid for itself several times over within a year. It has reduced raw material purchases by allowing the company to purchase only base colors. It allows for effective mixing of even very small batches, reduces mixing time to about 3-4 minutes, and allows us to keep much better record of ink inventory.

Water-based inks are better environmentally and for human health - (fire hazard, solvent fumes, ease

of disposal.) Inventory has been reduced by over half and sales have doubled. Insurance costs have decreased. Color consistency and colorfast characteristics have improved.

Case Study 10

The Spirit of Innovation

Martha Ortmann
Boxboard Containers, pg. 32-33

Lawrence Paper decided to retrofit its printing stations with a new, more efficient doctor blade system. The original open system was too costly in terms of ink consumption and contamination. Printco is a company that does retrofittings on printing presses. The retrofit involved many weeks working with the intricacies of the press, and engineering and redesigning the plate system. The new system saves ink and improves print quality. The blades are changed more often, and blade pressure is determined and adjusted automatically. Laser engraved anilox rolls are used as opposed to mechanically engraved ones.

Advantages of the new system: the old system used 30 to 40 lbs. of ink per ink change whereas the new system requires only 8 lbs. which reduces ink usage and volume of ink contaminated; blades can now be changed in 20 minutes versus an hour with the old system; the new system is detachable, making repairs easier.

Lawrence Paper recycles 100 percent of the water used in the printing process.

Case Study 11

Waste Minimization Assessment for a Manufacturer of Product Carriers and Printed Labels

Waste Minimization and Recycling Report, 1994
Government Institutes, Inc.

A plant manufacturing printed polystyrene packaging labels and high density polyethylene (HDPE) product carriers with over 400 employees produces 8 billion labels and over 500 million product carriers each year.

Wastes produced include volatile emissions (from the polystyrene extrusion process from the blowing agent Freon-22TM and impurities in the polystyrene); photoprocessing wastes; plate washing wastes (butanol/perchloroethylene solvent mixture), both liquid and volatile emissions; damaged or obsolete plates; solvent inks; press washing solvents (liquid and volatile emissions); defective product; wastes from the thermoforming and cutting process.

Solvents are recovered with two large distillation units and reused in the plant; all extrusion wastes that have not been inked are reground and reworked onsite; off-spec inks and surplus inks are reworked; ink runs are scheduled to allow light-to-dark transitions in the printing trays; wash-up solvent is recovered onsite for reuse.

The economic savings from the waste minimization opportunities implemented result from the need for less raw material and from reduced waste treatment and disposal. Additional waste minimization opportunities are listed in the case study.

Case Study 12

Thinking Positive about Compliance Pollution Prevention through Process Improvement

Fred Shapiro
Polymers, Laminations & Coatings Conference: 315-320
1991

A flexographic printer of stationery items and coating paperboard with overall solid colors was concerned with disposing of wastewater. Corporate engineers estimated the volume at 50 gallons per day, but further inspection revealed that one press operation alone was generating about 1,000 gallons per week. Examination of the printing process also revealed poor scheduling, untrained personnel, unsound practices in sequencing of colors, inadequate accessory equipment to facilitate efficient changes of color, and using free running water to clean parts during changes. A wastewater treatment unit was installed at a cost of $40,000 - $50,000.

Added ink pans and ink pumps helped make color changes more efficient. A cleaning tank was purchased so parts could be cleaned while the press was running, reducing the length of time it took to change colors and the amount of water used. Improved scheduling of colors eliminated some of the cleanup as well. Savings in downtime alone amounted to over $100,000 per year.